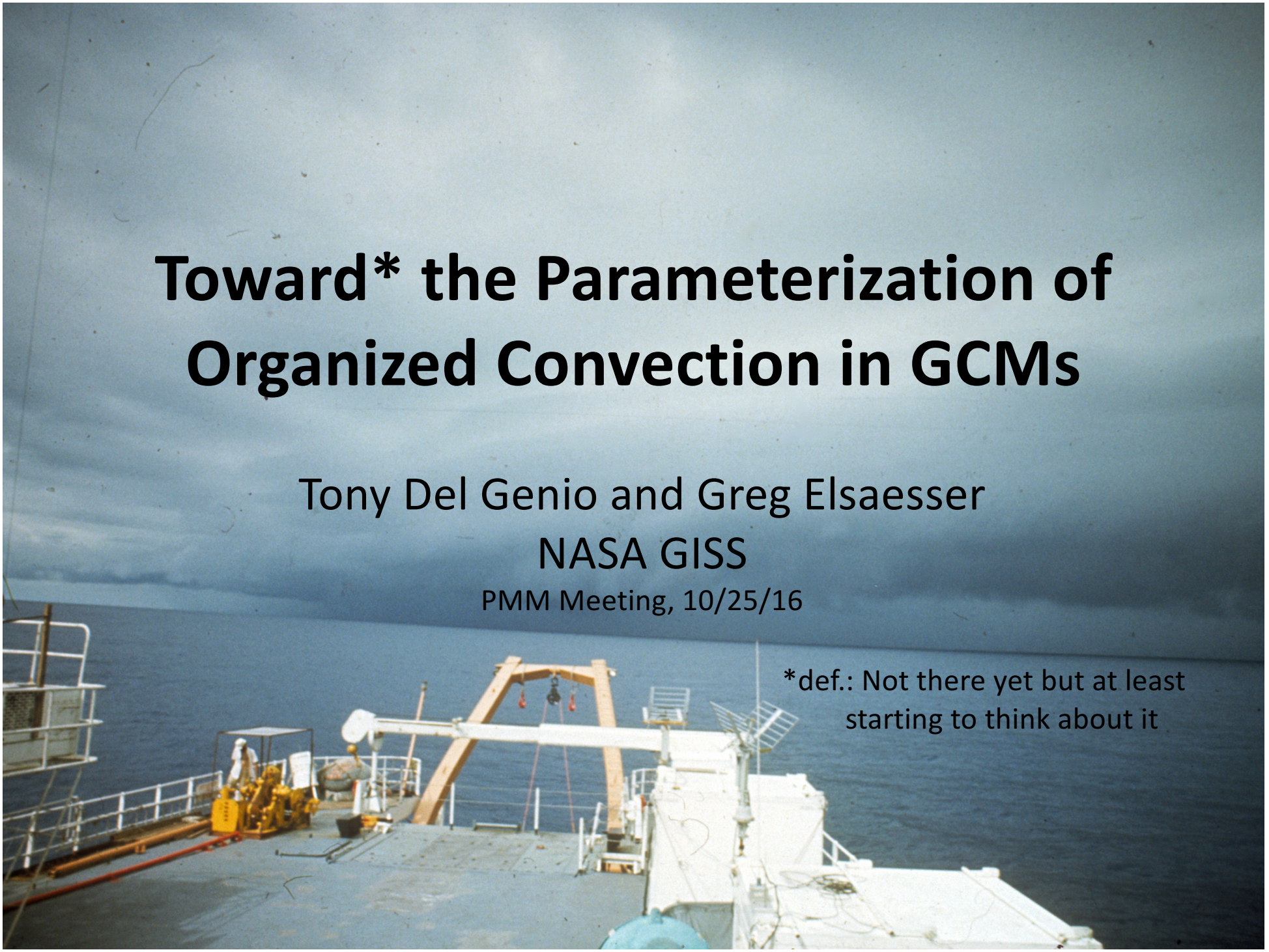


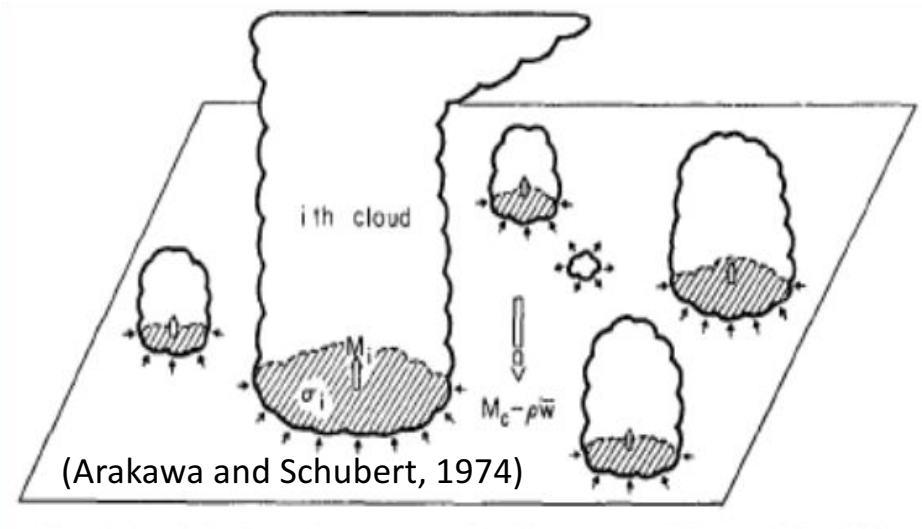
Toward* the Parameterization of Organized Convection in GCMs

Tony Del Genio and Greg Elsaesser
NASA GISS

PMM Meeting, 10/25/16

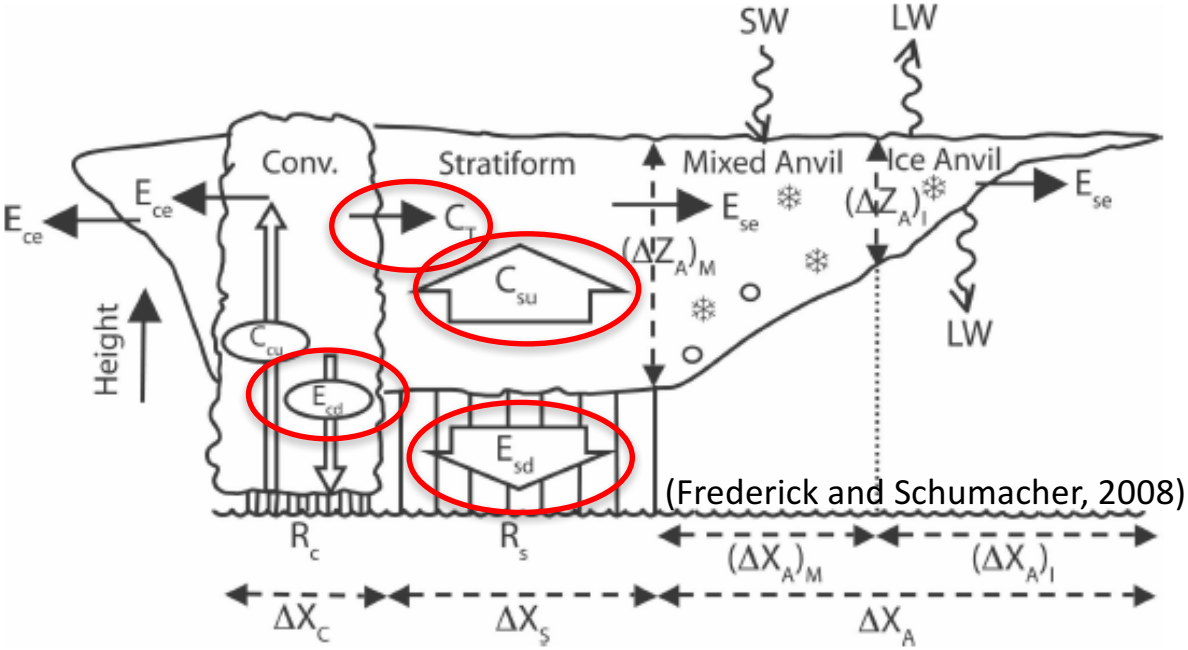
*def.: Not there yet but at least starting to think about it

GCMs see convection like this…



(Arakawa and Schubert, 1974)

But sometimes it's more like this.



(Frederick and Schumacher, 2008)

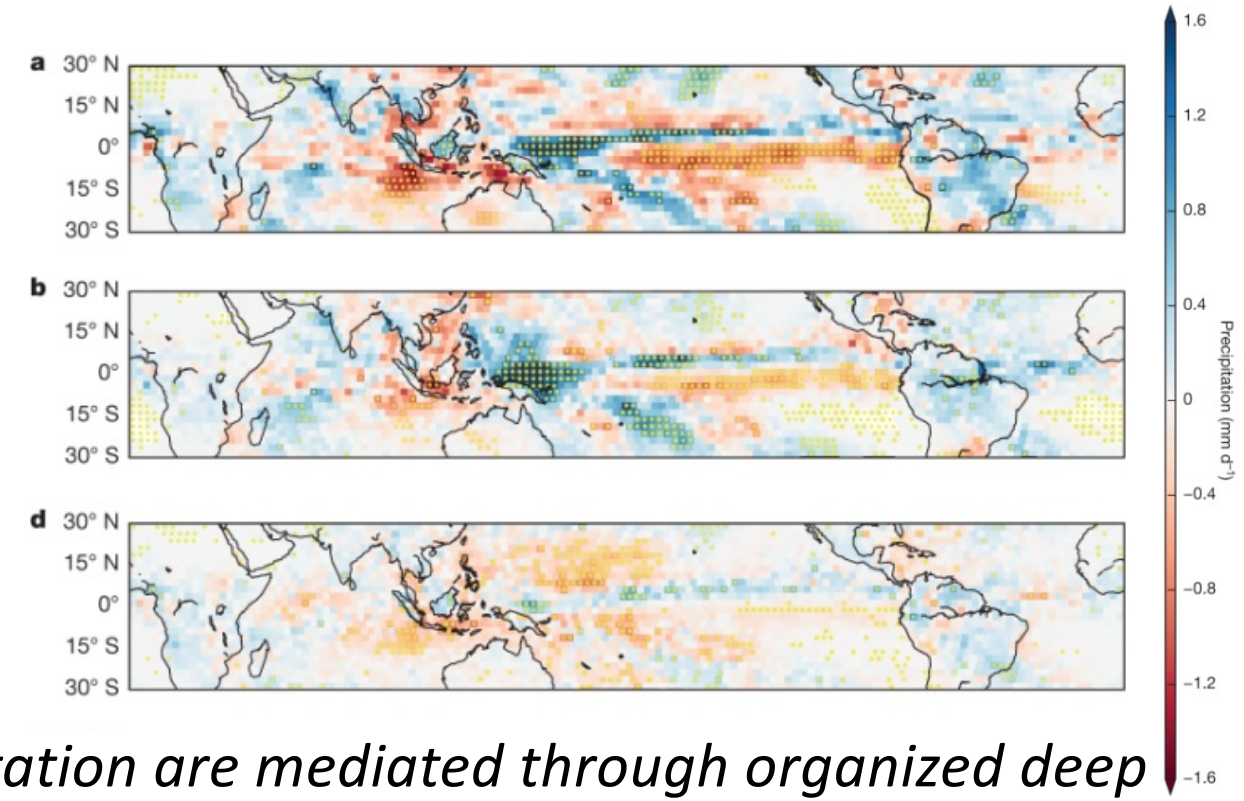
And it matters: Heating profile, momentum transport...

...and rain

TRMM 3B42
ΔP 1998-2009

Contribution from organized convection

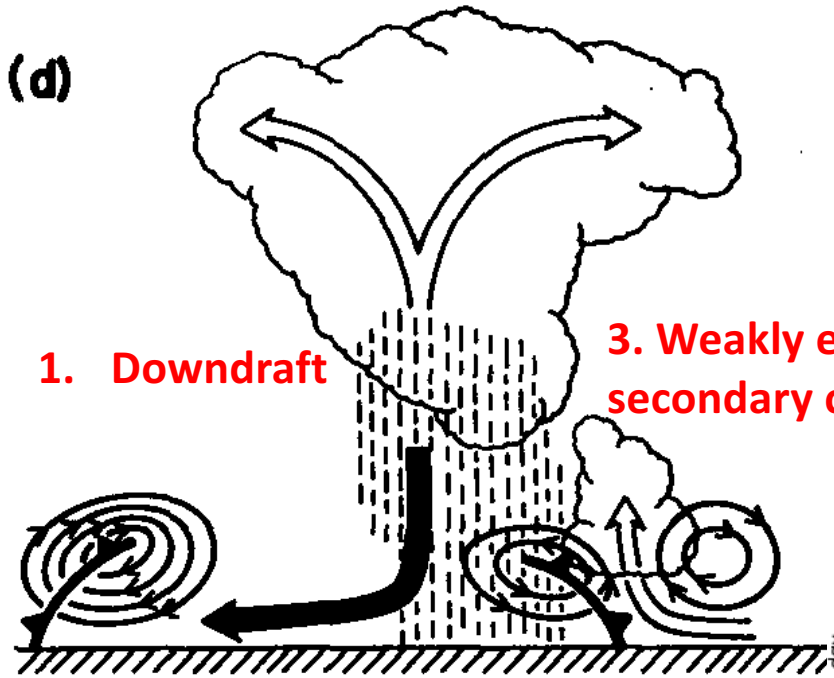
Contribution from other convection



"If changes in precipitation are mediated through organized deep convection, this calls into question the ability of global climate models (GCMs) to predict changes in rainfall accurately, especially in extreme precipitation…Given the societal importance of accurate precipitation projections in a warming climate, the role of organized deep convection in changes in precipitation...calls for a renewed effort to include a representation of convective organization in GCMs." (Tan et al., 2015, Nature)

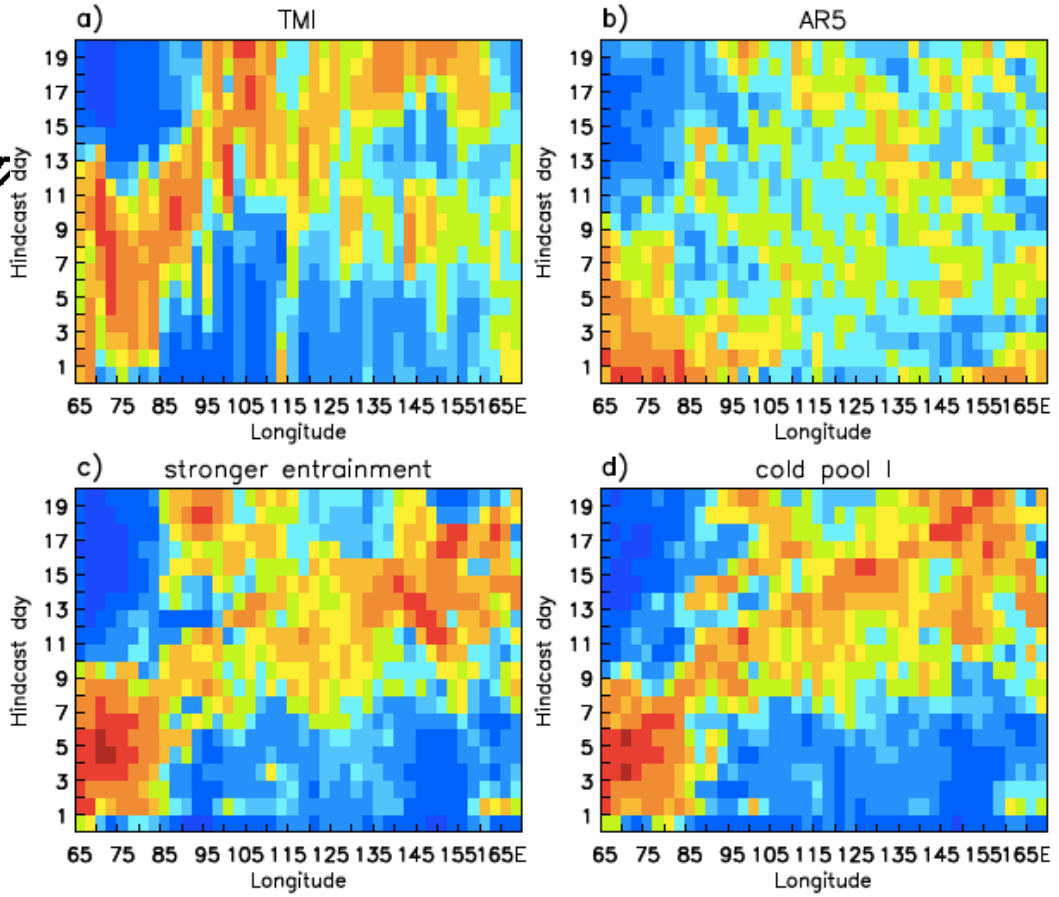
New cold pool parameterization in GISS GCM

(Del Genio et al., 2015)

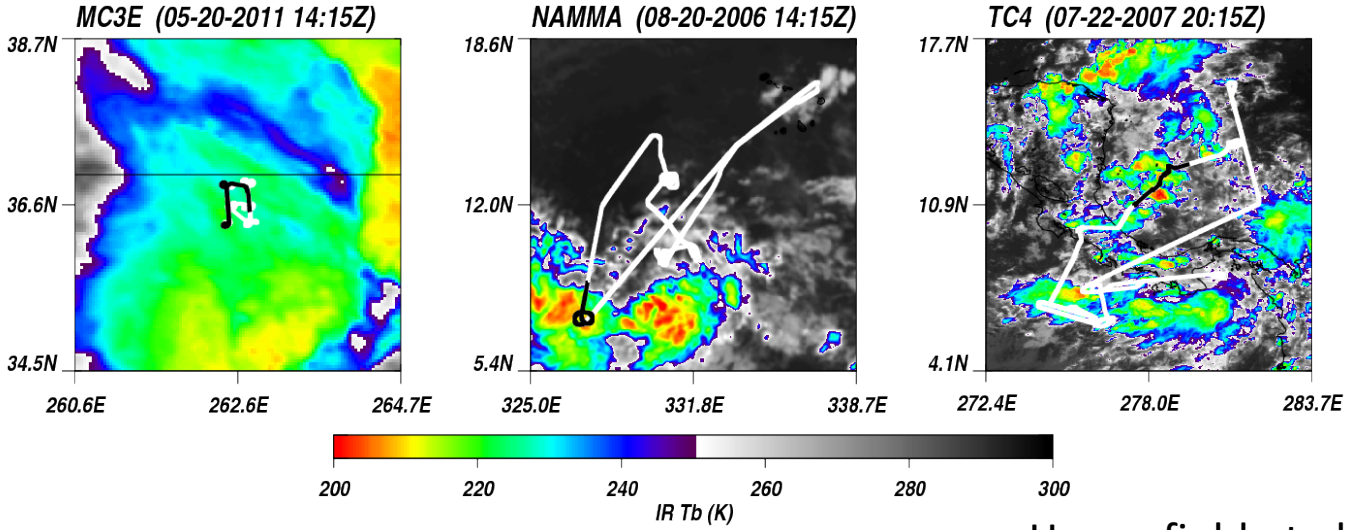


YOTC 20-day rain hindcast Hovmöller diagrams

(0.63 correlation with TMI over 20 days with cold pool vs. 0.70 TMI-PR correlation)

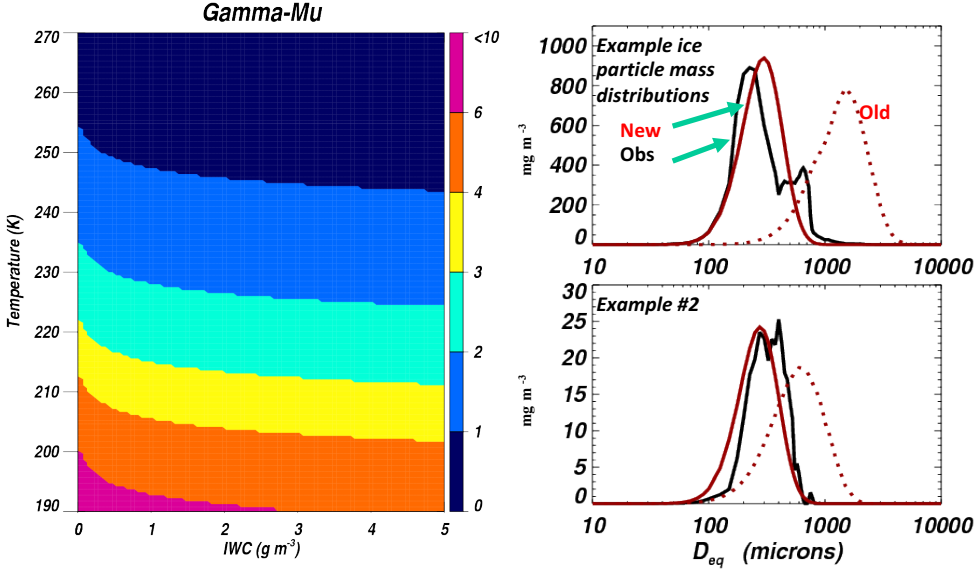


Detrainment informed by field experiment data (Elsaesser et al., 2016)

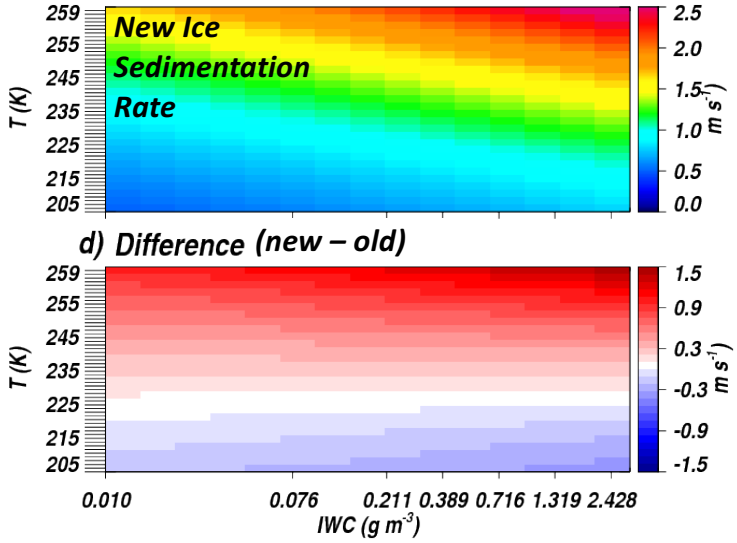


MC3E, NAMMA and TC4 in situ PSDs from flight legs close to deep convection (black line segments)

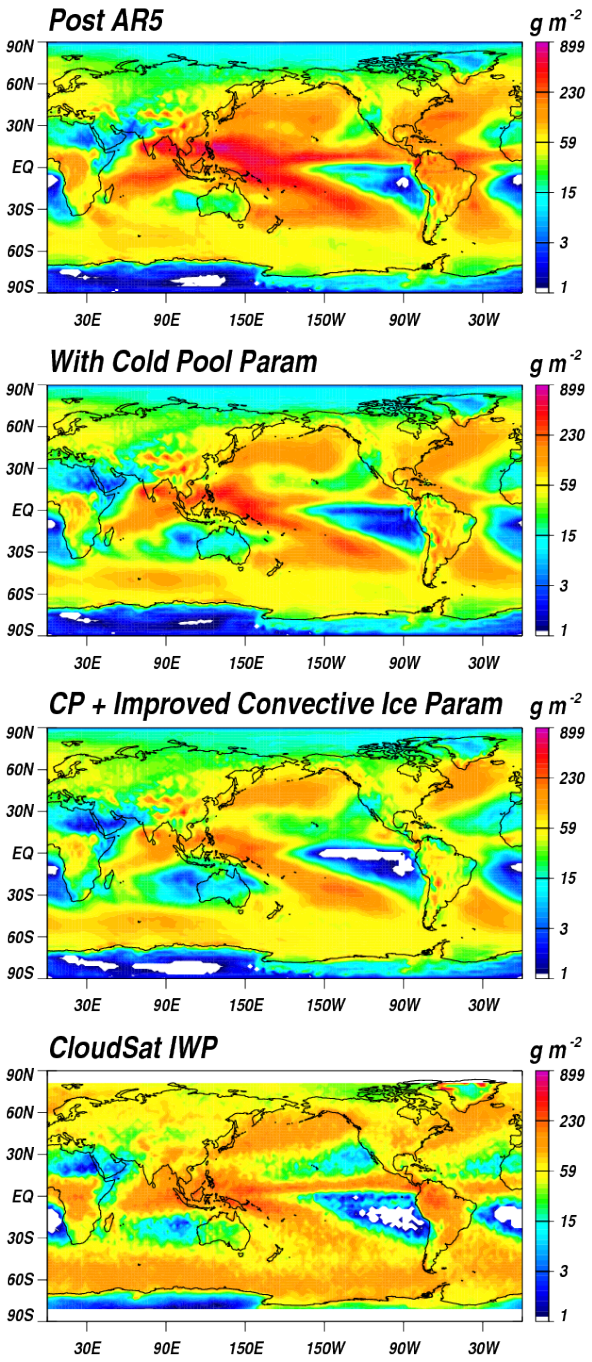
Gamma distribution fits to PSDs, with gamma-μ varying with IWC/T. Example fits (red) to obs. particle mass PSDs (black), new vs. old model

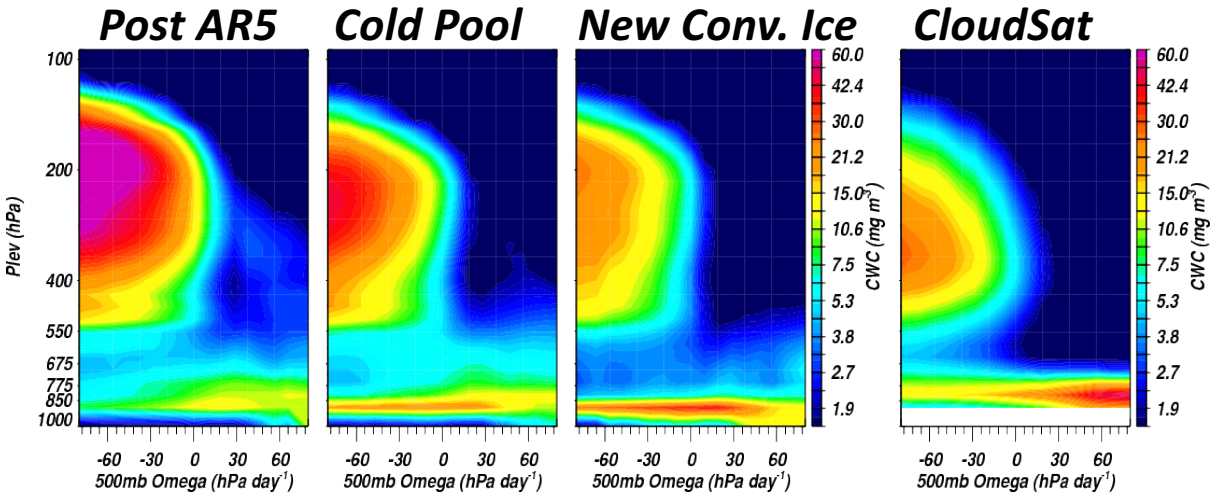


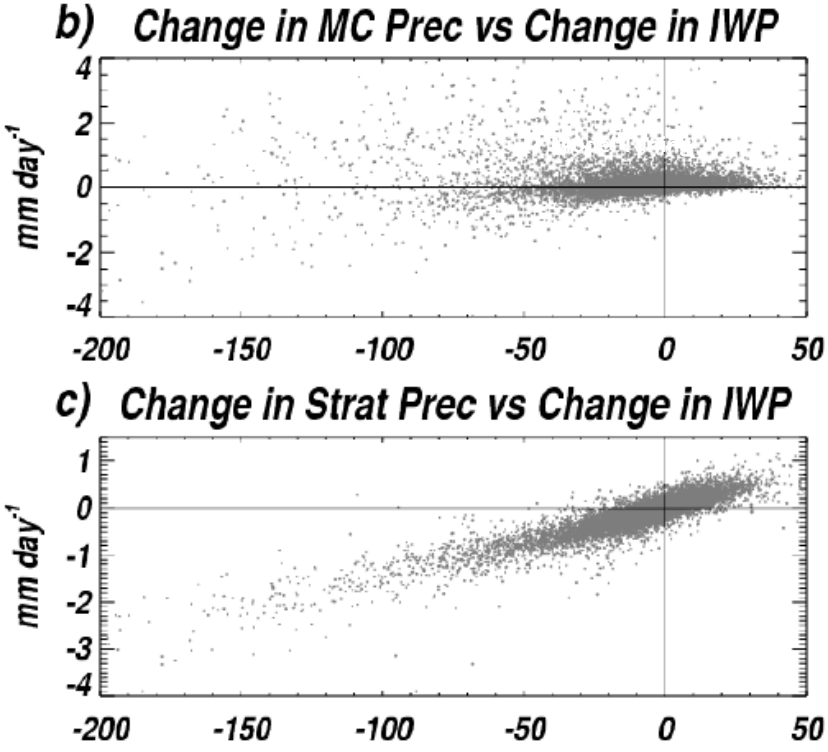
Heymsfield et al. (2013) formulations for particle $V_{fall}(D)$: smaller particles but faster fall speeds



GCM Simulations vs. CloudSat

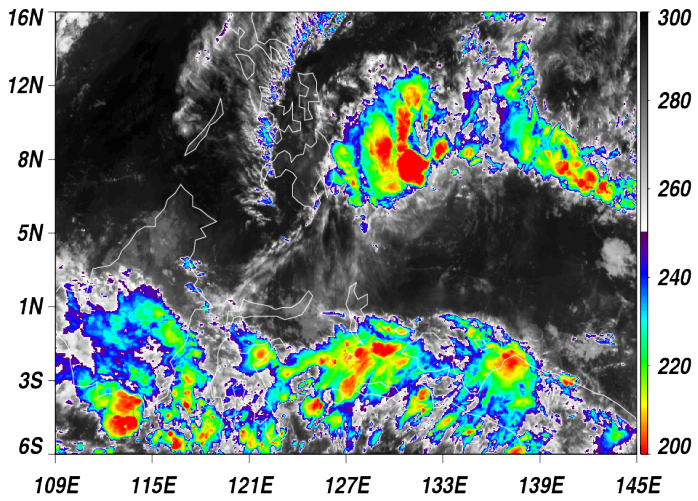


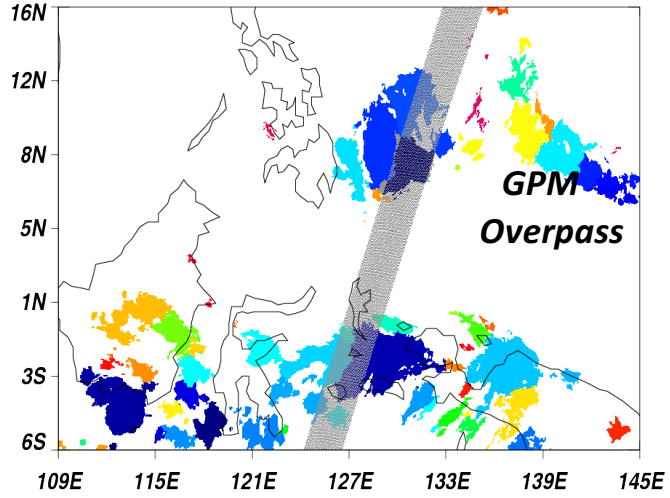




(Elsaesser et al., 2016)

GPM overpasses mapped to IR-defined convective systems: Starting point to identify MCSs and environments in which they occur, grow, and dissipate





Systems identified and tracked through lifecycle in CPC Globally Merged IR product (~4 km, 30 min) using Fiolleau and Roca (2013) algorithm: ~20K systems, 3/14-12/14

GPM retrieved quantities mapped to system lifecycle stage at time of overpass (**red = today's talk**):

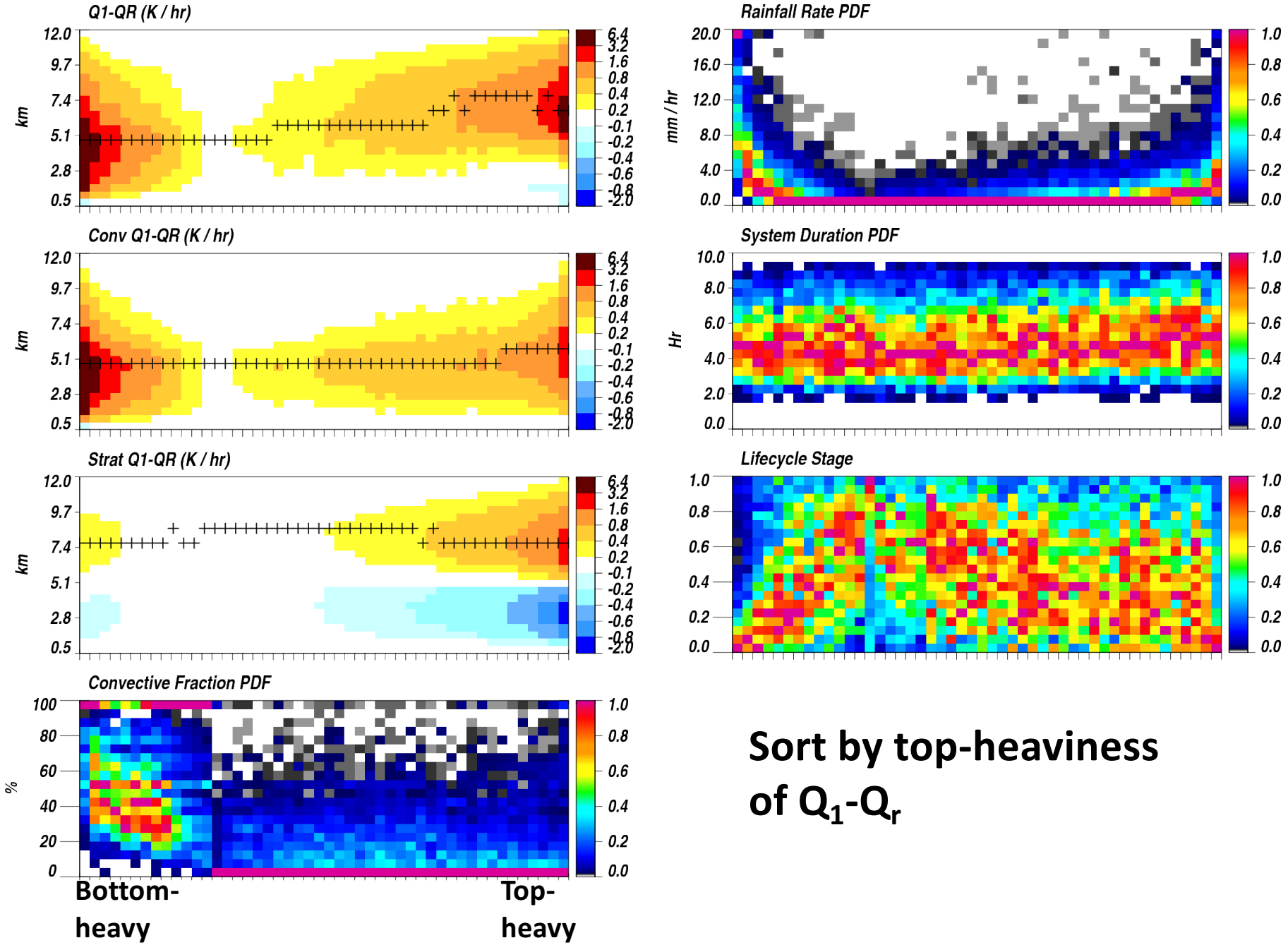
- **SLH Q_1-$Q_r(z)$**, LH(z), $Q_2(z)$
- **DPR Conv/Strat Flag (2ADPR)**
- **DPR Rain Rate**
- Precipitation Top Height
- CSH $Q_1(z)$, $Q_2(z)$ components
- Co-located T/q(z) – Reanalysis

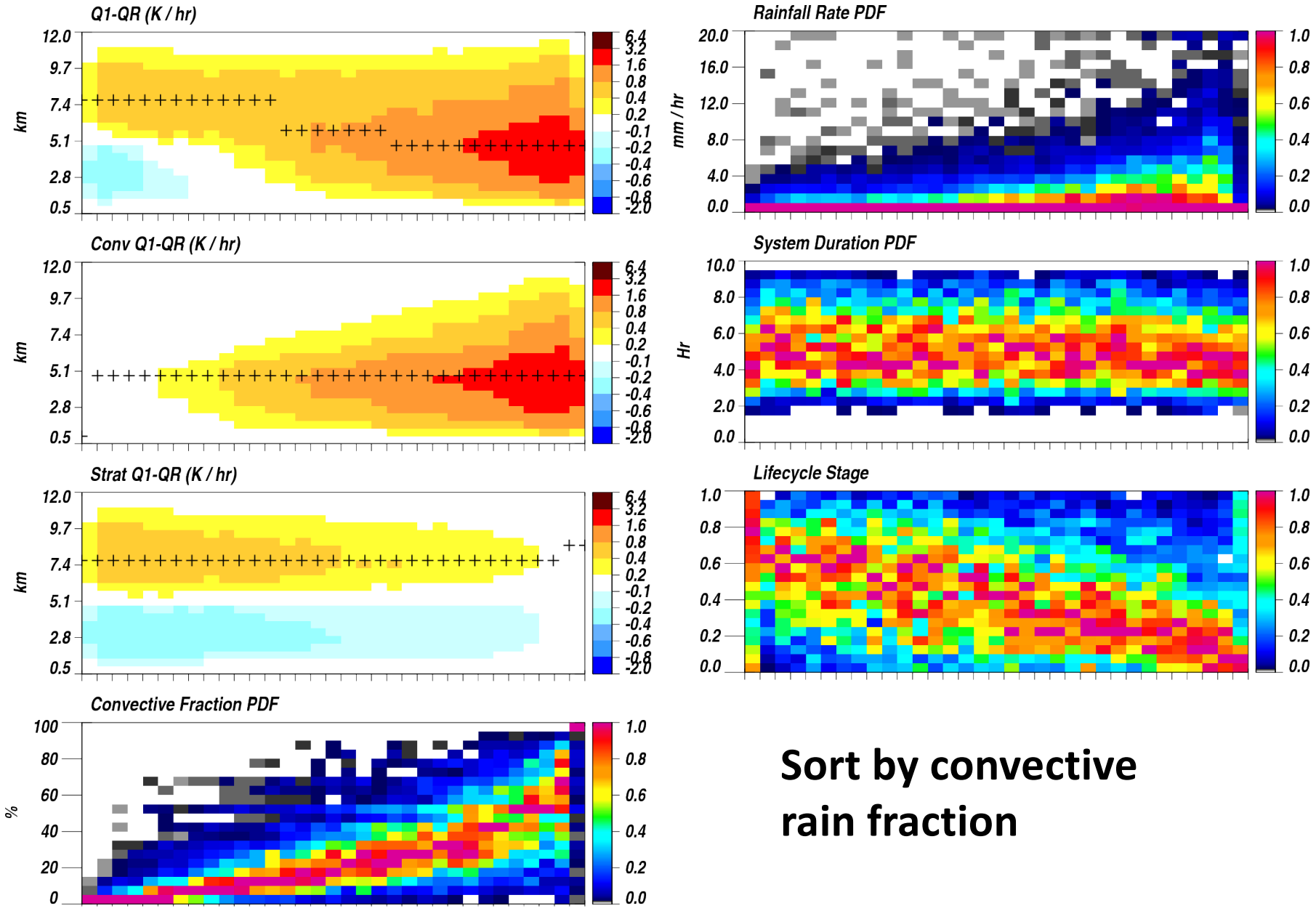
(Elsaesser-DelGenio poster)

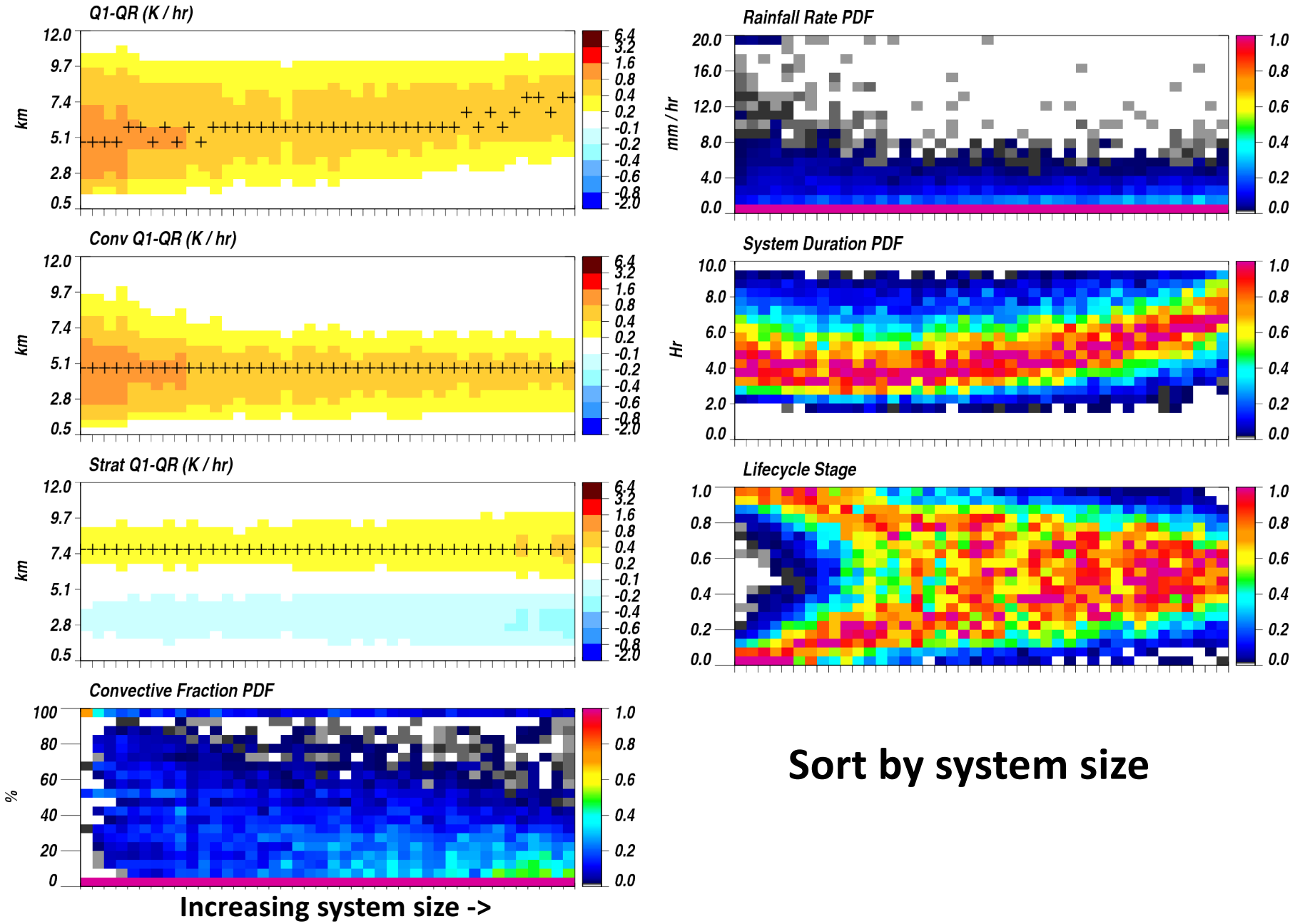
Question: What differentiates organized from non-organized convection in GPM data?

- **Top-heavy heating profile?**
- **Large stratiform/convective rain ratio?**
- **Larger size?**
- **Longer duration?**
- **Later in lifecycle?**
- **_____ (insert your favorite here)**

How to predict *whether* convection organizes, how big it gets, how long it lasts?


Q1-QR (K / hr)
Conv Q1-QR (K / hr)
Strat Q1-QR (K / hr)
Convective Fraction PDF
km
%
Rainfall Rate PDF
System Duration PDF
Lifecycle Stage
mm / hr
Hr
Bottom-heavy
Top-heavy
Sort by top-heaviness of Q_1-Q_r


Q1-QR (K / hr)
Conv Q1-QR (K / hr)
Strat Q1-QR (K / hr)
Convective Fraction PDF
km
%
Rainfall Rate PDF
System Duration PDF
Lifecycle Stage
mm / hr
Hr
Sort by convective rain fraction
Increasing convective rain fraction ->


Q1-QR (K / hr)
Conv Q1-QR (K / hr)
Strat Q1-QR (K / hr)
Convective Fraction PDF
km
%
12.0
9.7
7.4
5.1
2.8
0.5
100
80
60
40
20
0
6.4
3.2
1.6
0.8
0.4
0.2
-0.1
-0.2
-0.4
-0.6
-0.8
-2.0
Rainfall Rate PDF
System Duration PDF
Lifecycle Stage
mm / hr
Hr
20.0
16.0
12.0
8.0
4.0
0.0
10.0
6.0
2.0
1.0
0.6
0.4
0.2
Increasing system size ->
Sort by system size

Summary:

- 42 years after GATE, maybe it's time for GCMs to acknowledge the existence of organized convection?
- Parameterization of cold pools helps produce persistent convection that organizes on large scales (e.g., MJO) in GCMs
- Field experiment constraints on PSD and v_T can be exploited in GCMs to produce reasonable IWP, with implications for convective-stratiform rain partitioning
- No single property uniquely identifies organized systems in GPM data, but each provides its own insights; Q_1-Q_r and convective rain fraction seem to be good first choices
- A journey of 1000 miles begins with a single step – finally taking the first steps